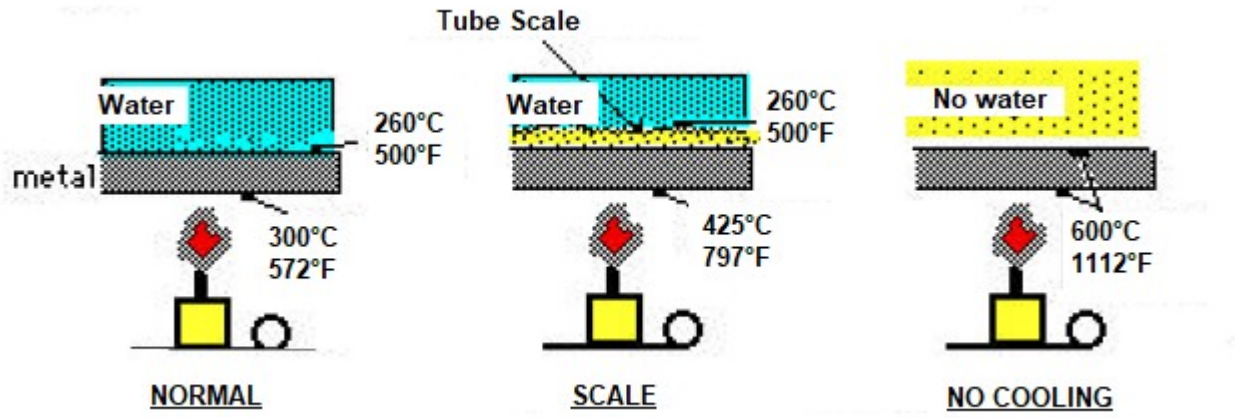
CHAPTER 6: EMERGENCIES

The boiler is an element subjected to internal pressure: this pressure subjects the metal "walls" of the boiler to very high stresses (the force on the walls is equal to the surface area times the pressure in coherent units, that is: kg/cm² x cm² = kg or lb/in² x in² = pounds, and this stress will depend on the geometric shape and thickness of the material).

Therefore, we must keep in mind that the stress in the material in a low-pressure or high-pressure boiler is the same, since its thickness will be proportional to the pressure and dimensions. This means that there are no safe boilers; all are boilers and must be treated as such, due to the risk of explosion.



Temperature at which the metal of the boilers can be found under normal conditions or in case of alterations.

But let's consider that this metal is also subjected to high temperatures (very high on the fire side and lower on the water or steam side).

However, if there are deposits on the water side, i.e., scale or sludge, the poor heat transfer from the "fire" to the water and steam means the metal wall doesn't cool down quickly enough, and the metal temperature can become very high, to the point of softening and stretching under the pressure, or simply "burning."

And it is also subject to temperature variations (as combustion conditions and pressure on the water side change, in addition to the possible—and not advisable—feeding with cold water, the metal will

be subjected to a "bellows-like expansion and contraction" similar to that of a bandoneon, which fatigues the metal, like "cutting a wire by repeatedly bending it").

These physical variations in the metal, among other things in fire-tube boilers, can cause the tubes to loosen on the mandrels in the plates and cracks in the plates themselves, causing leaks and a possible accident.

This variation in boiler dimensions, due to temperature changes—more than 1.2 mm per meter for every 100°C (212°F) variation—necessitates that the boiler have a support system at its base, the floor that supports it, to allow for expansion and contraction. Otherwise, in a boiler, this can cause stress corrosion in the casing or dome.

Over time, this can lead to an accident, since the casing can be perforated at the joint between the support leg and the casing itself —a very serious accident if it occurs.

These elements that facilitate expansion and contraction, generally at the base of the boiler (legs), must be kept free and lubricated if necessary to prevent them from seizing up.

Example:
A boiler with a distance of 5,000 mm (5 m) between its front and rear legs, and operating at 10 kg/cm² (142 PSI), with a temperature of 183°C (361°F) at the boiler body, has a thermal expansion difference between the casing (between the legs) and the support base of:

(183°C - 25°C) / 100°C x 1.2 mm x 5 m = 9.48 mm

This 9.48 mm (nine and a half millimeters) difference must be absorbed by the expansion system between the boiler's initial temperature (cold) and its operating temperature (183°C, 361°F).

To the above, we must add the fact that heat transfer to water, even when the surface on the water or steam side is clean, depends on the velocity of the water or steam over that surface (for example, if we want to cool food in a container more quickly with water, we agitate the water surrounding the container and stir the food).

In the boilers we are considering, water circulation depends on its "natural circulation" (in Uruguay, most boilers use natural circulation, although there may be boilers with forced circulation using pumps, such as the large ANCAP boilers, and smaller coil boilers in industry).

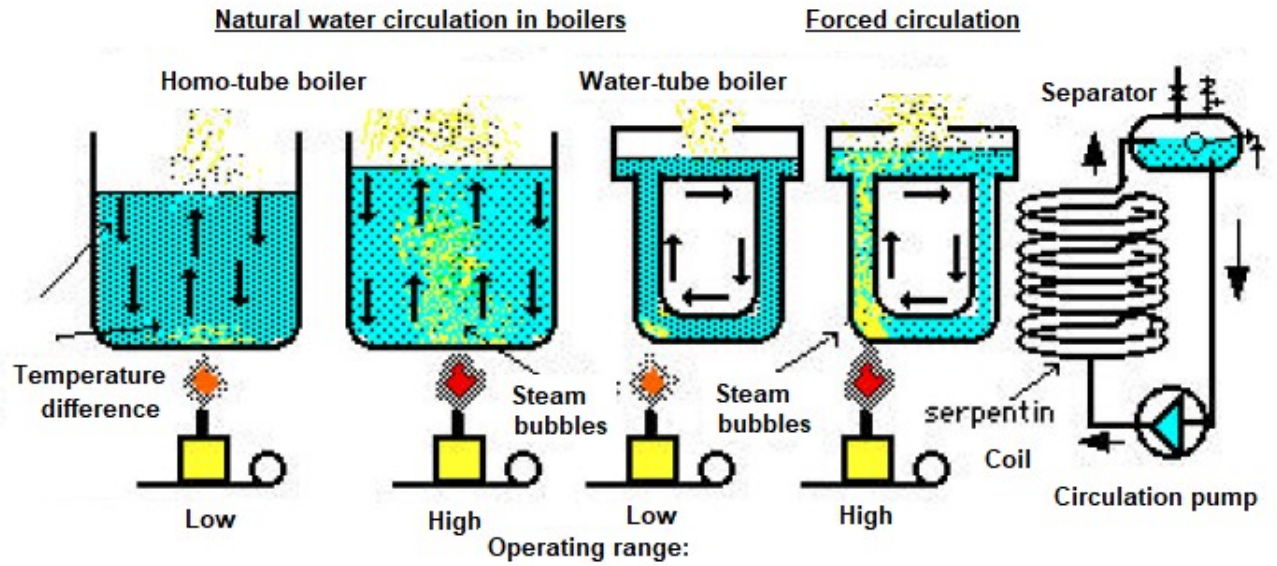
This natural circulation is caused by two factors: the difference in density (weight per unit volume) between the hotter water (which is lighter and rises) and the colder water (which is heavier and sinks), and the formation of steam bubbles inside the water (against the heating surfaces).

These bubbles, being lighter than the water, rise and contribute to the water circulation (this can be observed in a container of boiling water).

Both causes of circulation are carefully studied during boiler design. While these circulations can be intense, they are easily disrupted, potentially leading to insufficient cooling and overheating of the boiler material.

This can cause fatigue (cracks), deformation, or burning (combustion with oxygen from the air or from the decomposition of water or steam).

This leads us to consider that the internal circulation of boiler water (and steam in superheaters) are fundamental factors for the design and maintenance of the operation and integrity of a boiler.



This failure of the "natural" water circulation inside the boiler can be caused by several reasons.

These include: excessive combustion, a very steep drop in pressure with the fire at maximum, a pressure drop that is too rapid (opening

a large steam valve), and combustion occurring outside the designated area.

Due to wall breakage or poor control, local fouling from soot accumulation, etc.), blockages from sludge or scale buildup, tools left behind during repairs, or detached elements inside the boiler (plates, scale fragments, etc.).

Improper purge (the sludge collectors on the walls of water-tube boilers should not be purged when they are operating at a high rate of vaporization; the same applies to "caps" and gas generators),

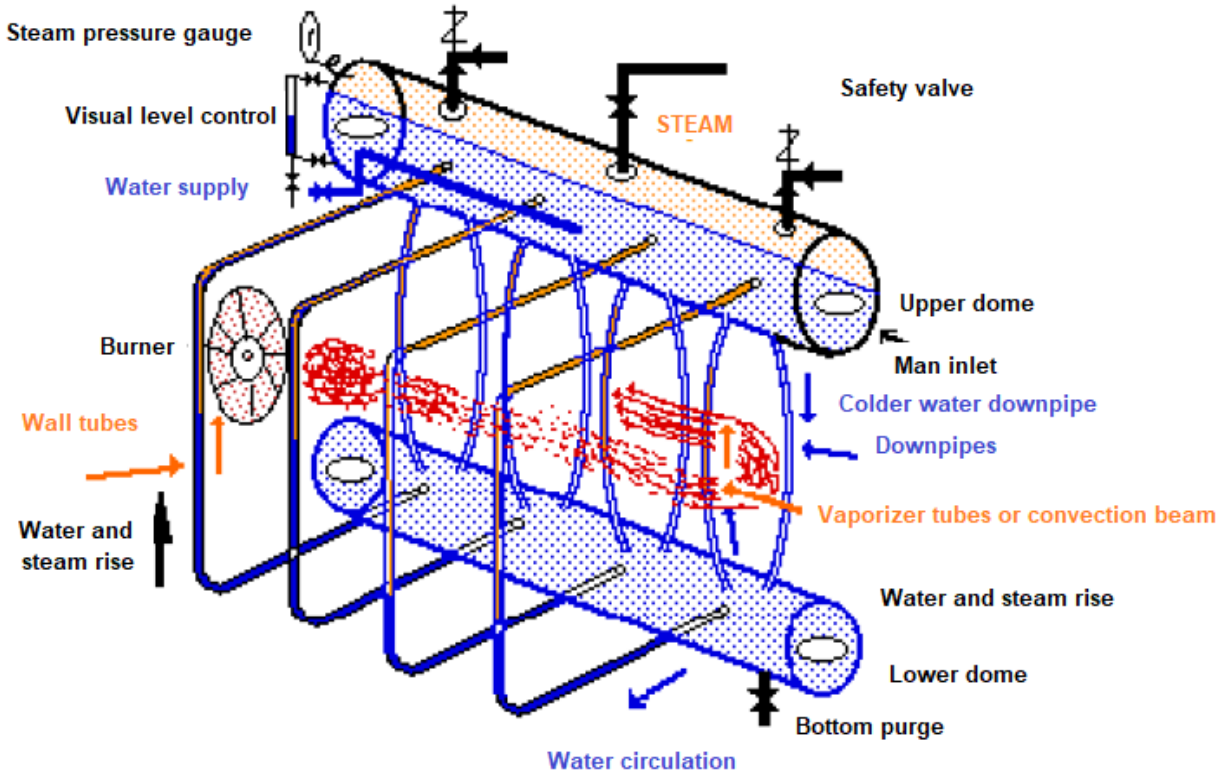
or due to a lack of chemical controls (very high levels of dissolved and/or suspended solids, very high alkalinity: high pH, contamination with organic elements, or improperly performed treatments: excessive dosing), etc.

In forced circulation, combustion is "locked" (dependent) on the pump operating or by means of a flow sensor (circulation flow detector), so that combustion ceases immediately when the water circulation stops.

Otherwise, the coil, lacking water circulation, would burn out.

As we can see, the boiler is a dynamic, complex element, and we must be attentive to sudden problems that may arise, which we will call "Emergencies."

To deal with these "Emergencies," we must be informed about how and why a boiler works, since, given the circumstances of an emergency, we won't have much time to think. This means the need for mental training for every situation that may arise.



Since "low water level" is the most significant cause of boiler accidents, we must pay close attention to this problem:

1.- Symptom: Low boiler pressure.

When boiler pressure drops, it is usually because the amount of combustion is insufficient to achieve the necessary vaporization.

But: be careful! Do not increase combustion before visually checking the water level: as it could also be due to insufficient water inside the boiler (if the water supply fails and the level control system—which shuts off the burner and sounds the alarm—is blocked, usually by sludge or scale, we risk making the mistake of increasing combustion manually or automatically).

This is the number one cause of serious boiler accidents.

The explanation is that when the water level drops, the heating surface that vaporizes the water is also exposed.

With the reduced heat transfer, less vaporization occurs, which is insufficient to maintain pressure (this is particularly serious in fully automatic burners, as combustion is regulated by pressure and should automatically shut off if the burner is functioning correctly).

In the case of the stoker, he is also guided by the pressure (although there may be a level control with burner cutoff and/or alarm, there is the alternative that if the stoker is attentive he will always check the water level as a primary control before increasing combustion).

Conclusion: Never increase combustion without first checking the water level, or if the pressure drops, check the water level immediately.

If the water level has dropped, first reduce combustion or turn off the burner, then quickly bleed the system to determine if the level is high or low (if the level is high, the water level will reappear when you bleed it; if the level is low, it will not reappear when you bleed it).

If the water level is low or has disappeared, immediately turn off the burner, shut off the water supply, and close the

steam valve.

This will prevent the boiler from running completely dry. Without combustion, no more steam will be generated, and if overpressure occurs due to the heat of the material, the safety valves will activate.

However, if we completely empty the boiler, it will overheat locally and its components will warp. A safety valve or another steam valve can be opened to slightly relieve the internal steam pressure.

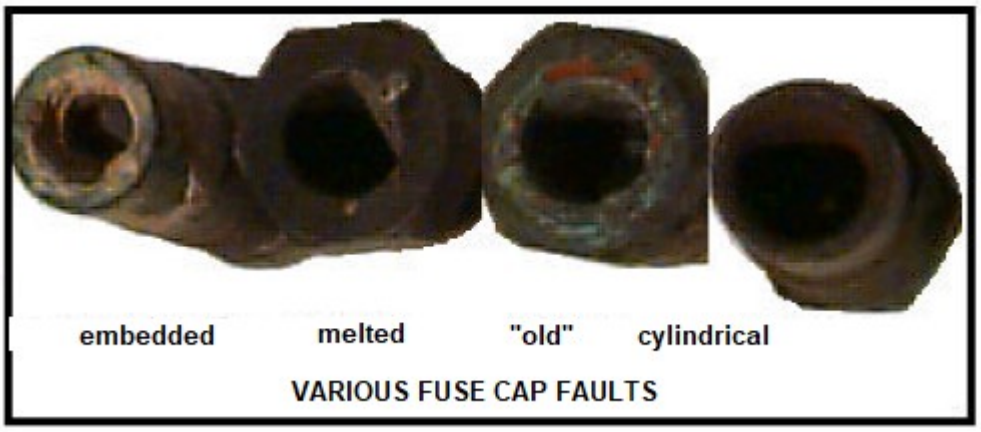
Almost completely close the air intake (leaving a small draft to maintain a gentle flow of gases in the combustion chamber, but this should be very small to avoid stress or combustion of the overheated metal).

If the boiler burns cellulosic materials (wood, husks, etc.), completely close the air intake so that no combustion occurs.

Do not add water if the water level is outside the visual level or below the lowest level test tap. Adding water to the boiler, which is relatively cold compared to the superheated metal, can cause damage ranging from warping to rupture of the material this can lead to a boiler explosion (due to internal pressure and material failure, although a true boiler explosion usually occurs when the boiler is completely empty and the metal is red-hot).

In the case of adding water, a true explosion or reaction occurs between the water and the superheated metal, producing a violent expansion due to the physicochemical reaction between the iron of the boiler and the oxygen-hydrogen in the water.

In this situation, the boiler should be allowed to cool to room temperature (with the burner off, water supply shut off, and steam shut off). Once cool, the entire boiler should be inspected, including the fusible plug (which should melt if the water level has dropped below it).

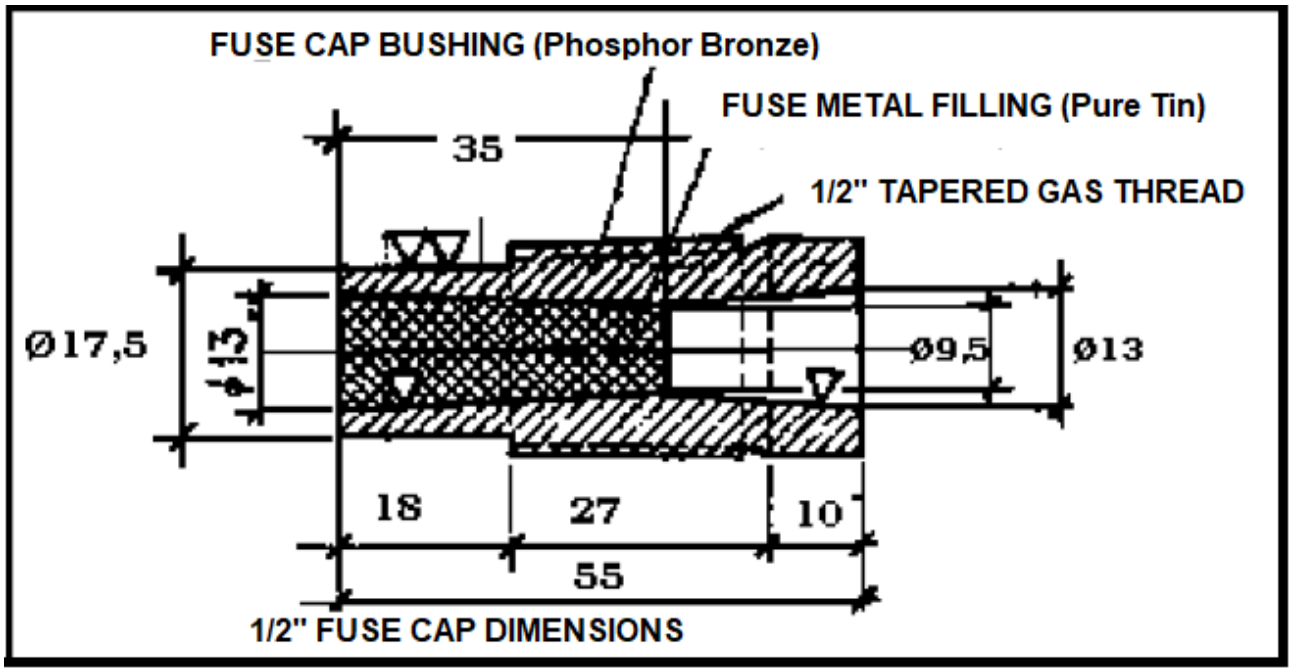


VARIOUS FUSE CAP FAULTS

If any overheated parts are observed (discoloration, deformation, loosening of tubes, etc.), a technician should be called for a more thorough inspection.

In any case, it is advisable to perform a hydraulic test before returning to service, after the visual inspection.

The fusible plug will not always melt, since if it is embedded, it may melt but not escape "vapor" because it is blocked by the encrustation (hence the importance of replacing fusible plugs at the expected times, between 6 months to a maximum of one year).

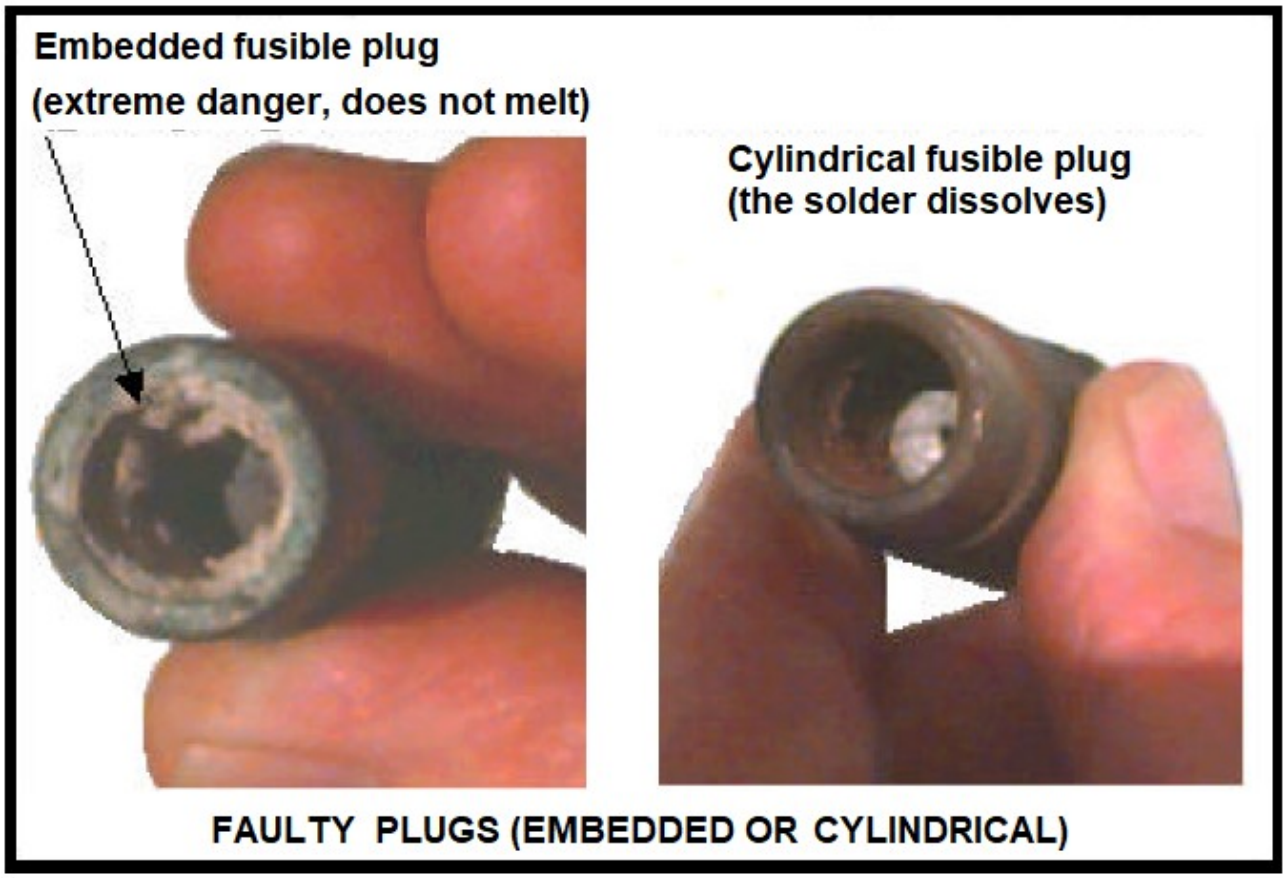


Generally, we can't say that a fusible plug can extinguish the boiler fire (the original reason for its invention, as well as release pressure), but its presence is very useful, since it indicates an anomaly (low water level or repeated, albeit subtle, low levels).

This gives the boiler operator a warning to take action, or the technician a telltale sign that can confirm a situation of doubt (whether there was a low water level or a physicochemical stress-activation problem in the water that altered the internal circulation, causing localized overheating that leads to material failure).

Also, if a fusible plug partially or completely melts, it's not

necessarily due to a low water level. It could be that the fusible plug wasn't manufactured according to strict standards, meaning issues with dimensions (tapering is very important; if the plug is cylindrical in the part where the tin is located, it's very likely to leak in a short time), tin quality (purity), or the casting process. (cleaning, temperatures, etc.)



INADEQUATE FUSE CAPS
Embedded fusible cap (high danger, does not "melt")
Cylindrical fusible cap (the tin dissolves)

In the event of a water level drop due to a "high level," with the fire extinguished or at minimum, the water level should be lowered quickly (by temporarily shutting off the supply and preferably purging from the surface: continuous purging).

The risk in this case is water carryover, which can cause a "water hammer" (water propelled at the speed of the steam, which, upon stopping, causes a "hammering" against the pipes or equipment) in the pipes or equipment where steam is used (this can be very dangerous in equipment such as dryer cylinders, kettles, etc.).

Also:

A high level can be caused momentarily by very high steam consumption (generally with a high vaporization rate or with very high water chemical limits).

In this case, it is advisable to slightly reduce the steam output to alleviate the excessive consumption.

Otherwise, if we purge the system, we can go from a high level to a low level once the peak consumption has passed.

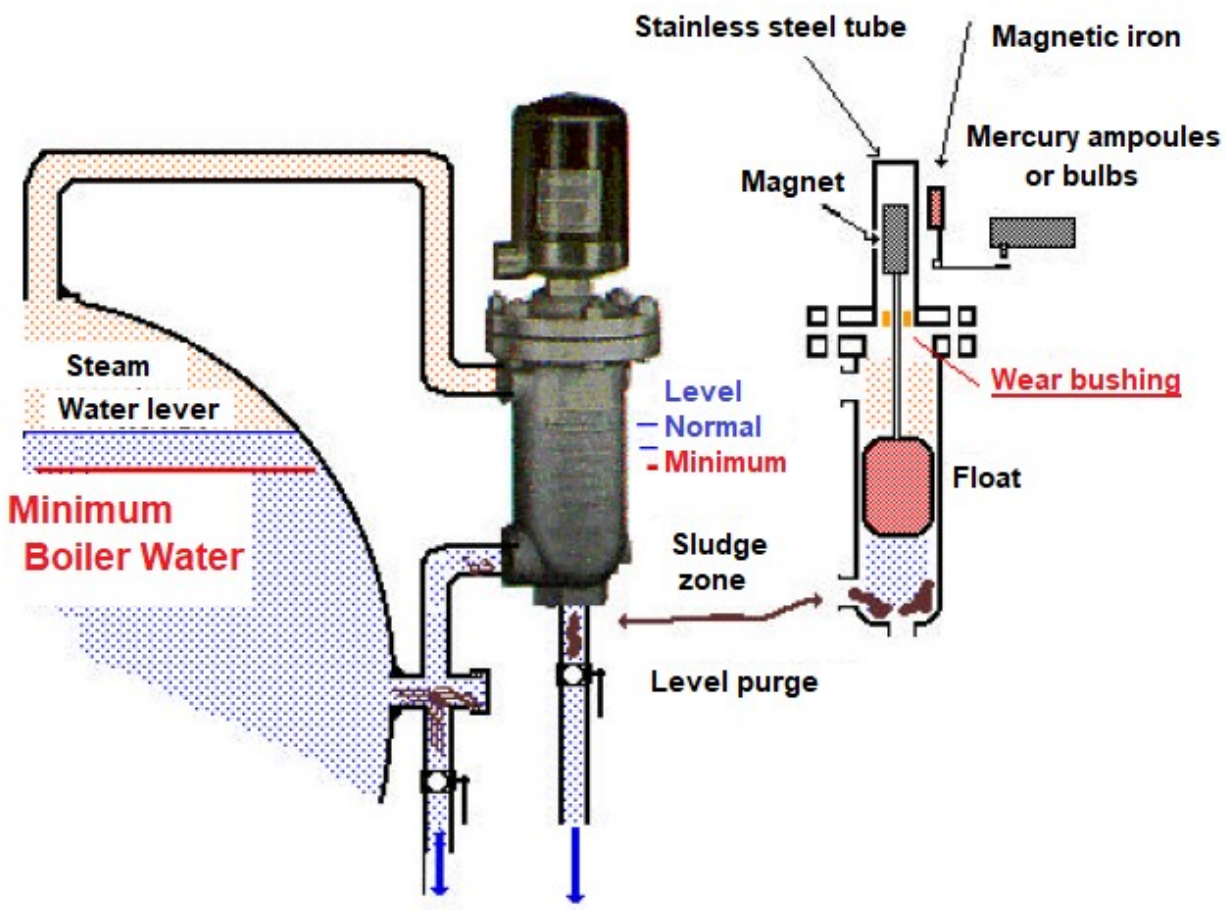
In float-based level control systems (McDonnell® and others), an excess level (or high level) can be caused in part by a "puncture" (a perforation of the float, which fills with water and loses buoyancy). This perforation is generally caused by corrosion (especially in stainless steel floats, which are attacked by chloride ions in well water or when salt from the softener enters the boiler, or by a lack of blowdown).

Or there may be a partial (or total) "collapse" caused in the float by being at the maximum pressure limit it can withstand. This can be caused by various reasons: a hydraulic test, a "water hammer" during purging, or the piping and valve system is inadequate, causing an excess of steam flow that strikes the float and begins to "crush," preventing it from withstanding the pressure as it loses its spherical shape.

Therefore, it should be purged as much as possible, slowly until fully open, which should not be an excessive amount, but (either because the boiler pressure has been high and the float is at the limit of the working pressure, or sometimes caused by a hydraulic test that exceeds the maximum pressure that the float can withstand**). In this case, the high level remains permanently and the solution is to change the float.**

When a buoy has a puncture, do not attempt to weld it; it is very dangerous (since the buoy contains water, and when heated for welding, the water vaporizes and creates high internal pressures that can cause the buoy to burst; serious accidents have occurred when attempting this type of repair).

Replace the buoy with a new one, but then investigate the cause of the failure.



In some float-type level gauges, where the float moves along a guide inside a bushing (as with Magnetrol® gauges), **the failure can occur either due to a problem with the float itself or a problem with the rod's movement within the guide bushing (which tends to jam).**

This is very dangerous because it can jam at a high level (causing a low level by preventing the boiler from being fed and eliminating the low-level cutoff, which is very dangerous) or at a low level (causing a high level and thus dangerous water carryover into the steam).

Water level failures are not only caused by mechanical component failures (such as in the float or its movement, or in the components associated with the buoy, including its lever or displacement mechanism), but also by the system that transmits the buoy's position to the electrical sensors. These sensors, which may have been mercury bulbs (which should no longer be used because mercury is a pollutant), are now replaced by micro-switches. These

are moved, under low pressure, by levers through a bellows, which allows movement but prevents steam from escaping.

This stainless steel or copper bellows can also be punctured or fatigued—causing it to crack—for the same reasons as the float: excess chloride ions (in the case of stainless steel) or ammonia (in the case of copper), or excessive pressure during hydraulic testing. This can cause the system to become flooded with steam, and the resulting humidity can further damage the system. "short circuits" that cause the indication of the mercury bulbs or the micro-bulbs to be false, potentially leaving the burner without low-level cut-off protection).

When the pressure is higher, in McDonnell® controls (or other float systems), instead of transmitting the float's movement via a "seal" element (a stainless steel or copper bellows), the linear displacement of a magnetic element inside a "non-magnetic" tube (copper or stainless steel) is used. This displacement is detected by small magnets that are attracted to an opposing spring as the magnetic element passes. These small magnets are connected to micro-switches, which open and close according to the water level.

The most common failure of these components, while it can be mechanical (float, displacement, mud, etc.), is that the micro-switches themselves can fail, or the mechanical system of the micro-switches can become fatigued and fail. Therefore, the following recommendations should be considered:

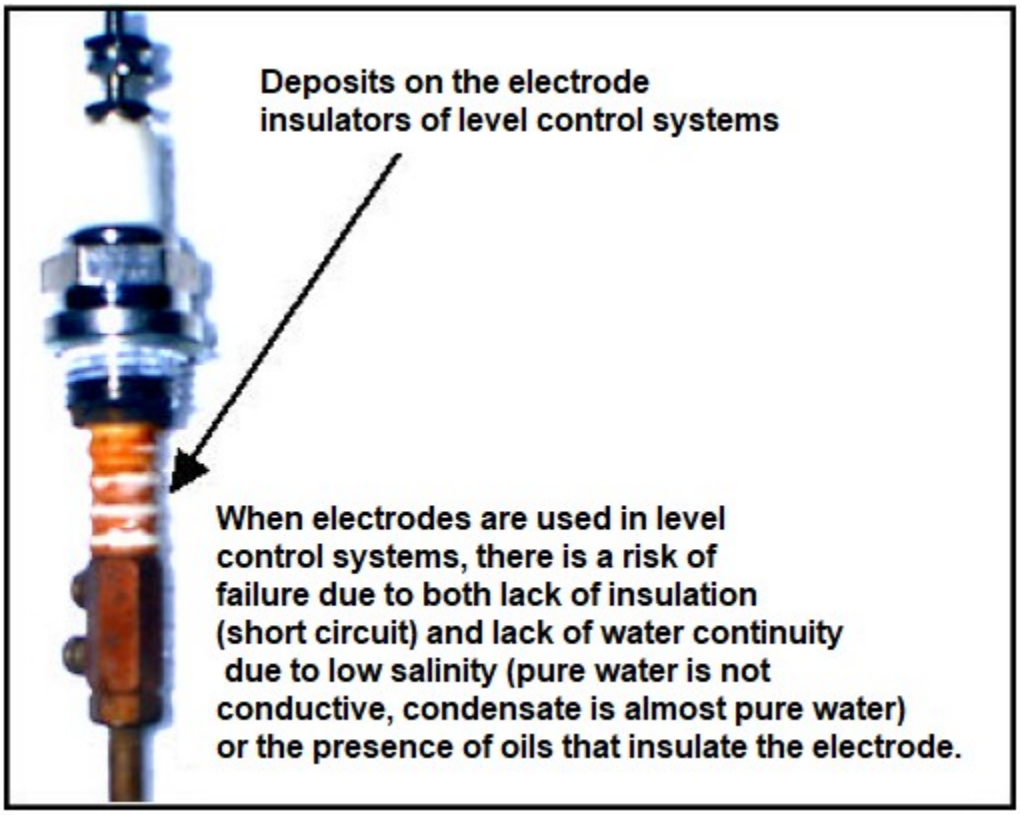
All level controls should be replaced every few years (as indicated by the manufacturer), but what cannot be done is to purge them improperly, since the lack of purging or poor purging practice (purging into "air" or "timid" purges) does not clean the internal part of the control, allowing the floats to "hang" on the deposited sludge, causing the boiler to run out of water and not shut off due to low level, which is very dangerous.

For all these reasons, **there should be at least two level controls (with burner shut-off in case of low level), the levels should be purged every four hours, and the burner should be checked to ensure it shuts off**.

Electrical cables should be replaced every five years (or as needed, using cables appropriate for the operating conditions, temperature, mechanical protection, and humidity).

It is often advisable **for each level control to have its signal drawn through separate electrical conduits to prevent a steam leak from a bellows from potentially short-circuiting the entire system**, as steam can travel through the protective conduit of the cables to the control panel itself and cause a major short circuit.

There is a current trend towards using electrode-based level controls (this is because they are less expensive than float controls). Companies like McDonnell® recommend that the level control heads and their electrodes be replaced every two years (this is due to the problem explained below).


Deposits on the electrode
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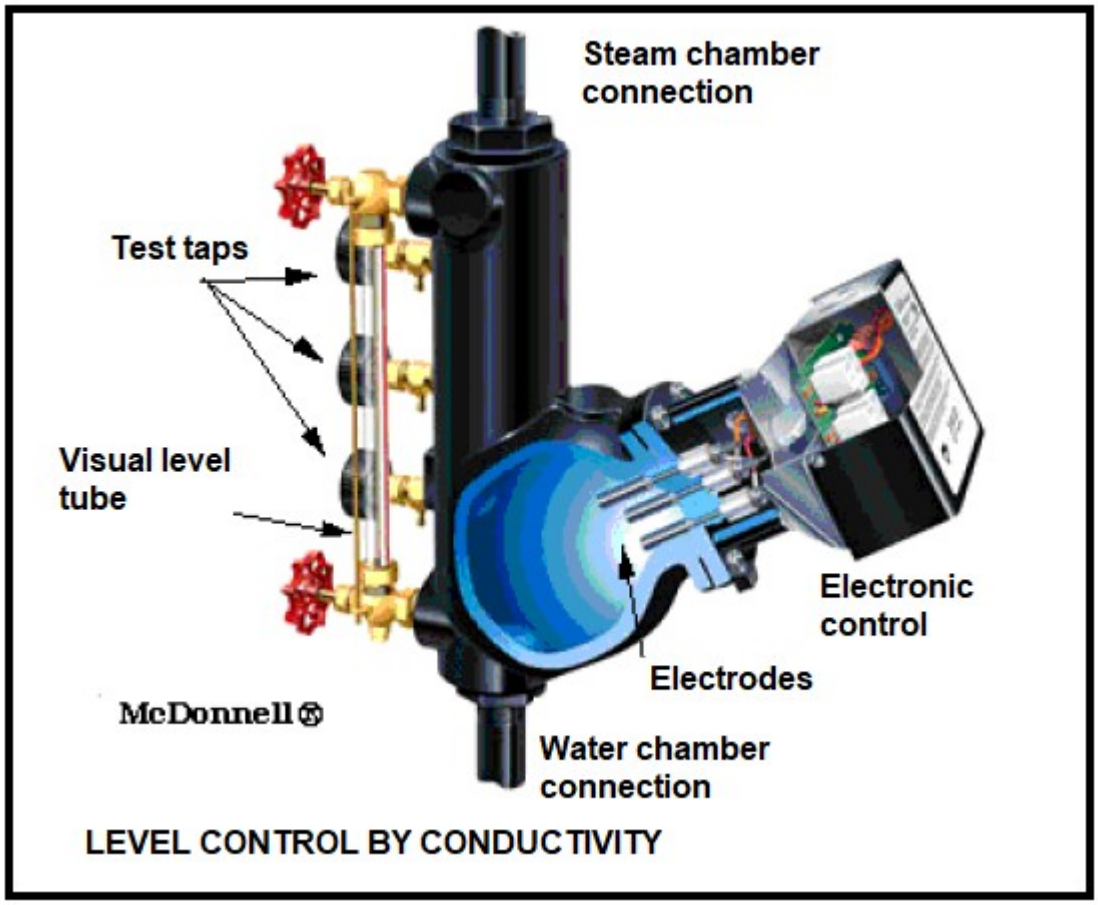
oils that insulate the electrode.

In my personal experience (CWT), I can say that these electric controls (which operate based on water conductivity), which were very popular years ago, have been phased out due to the risks involved (many boiler accidents were caused by these level controls,

since the conductivity of boiler water is highly variable, especially within the level repeater or copying tanks, where condensate, which has low conductivity, tends to accumulate, making it necessary to operate with high electrical "resistance," i.e., low water conductivity).

Therefore, the system must account for this situation and address the problem of insulator fouling, both internally and externally). The insulators tend to become fouled and cause false water level readings (we recommend cleaning the insulators, internally and externally, every 6 months to a year).



Another cause of level control failure is the current trend of

placing level controls on a large-diameter repeating column (this "pipe" that acts as a repeating column tends to become clogged as it fills with sludge at its lower end.

Since the sludge suspended in the water enters the base of the repeating column, it settles because the water moves very slowly due to the lack of internal circulation within the column. Steam condenses at the top and connects with the boiler water at the bottom, and level purging is insufficient to create a sufficient cleaning speed at the base of the column).

This failure of repeater columns is partially eliminated by placing a large diameter (1" or more) purge at the base of the column, in the shape of a T (although I am not in favor of repeater columns, they are energy inefficient; at the end of the year, the thermal losses due to their large exposed surface cost about 1,000 liters of liquid fuel or 1,100 m3 of gas or 3.5 tons of firewood 25%H.b.h).

2.- Lack of Water Supply

A lack of water level is very serious. Even with the fire out, it can cause tubes to loosen or localized overheating (leading to corrosion, fatigue, cracks, etc.).

As we have seen previously, we must prevent the boiler from losing water level under any circumstances. Therefore, we must do the following immediately:

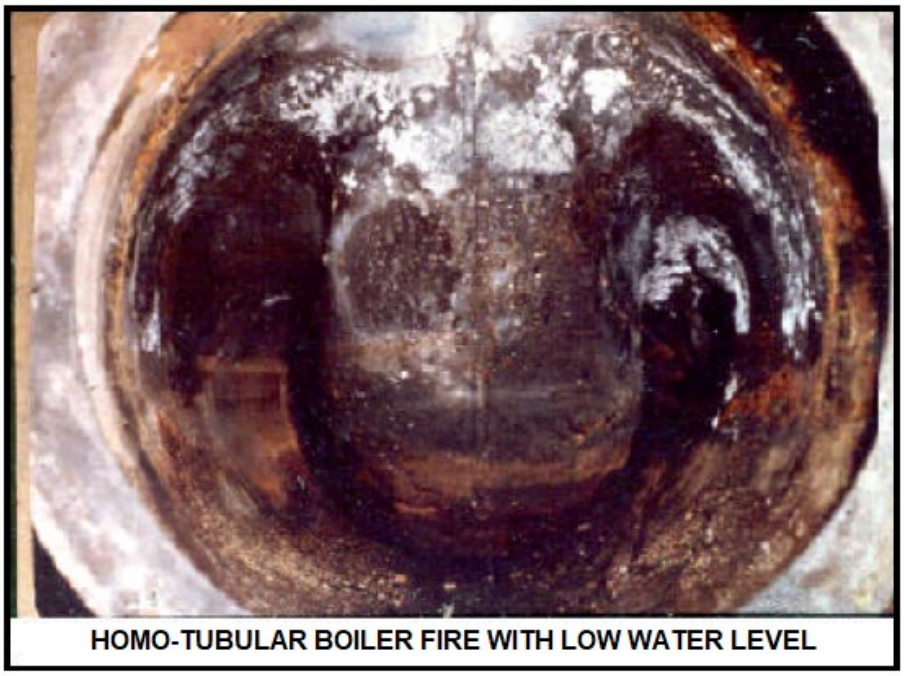
a.- If there is no feedwater: turn off the fire and shut off the steam.

b.- If there is a power outage (the feedwater pump is not working and there is no auxiliary feedwater supply: injector or alternative pump): **turn off the fire and shut off the steam to prevent the boiler from emptying and exposing the tubes or other heating surfaces.**

Insufficient water supply, if the burner doesn't shut off in time, can lead to boiler failure (due to burnout) or even an explosion.

This can occur whether water enters the boiler while it's overheated

or simply due to a failure of the pressure vessel as the material becomes unable to withstand the internal pressure. This is the most common failure (and can happen for many reasons).



HOMO-TUBULAR BOILER FIRE WITH LOW WATER LEVEL

3.-Boiler Leakage Failure

This could be a water or steam leak inside the combustion chamber or flue (perforated tubes, loose mandrels, cracks, etc.), or a leak in the outer casing (caps, manhole, casing cracks, connections to the boiler, etc.).

Turn off the burner, maintain the water supply until the boiler cools down, and allow air in if necessary to extract or expel the steam through the chimney. Release steam through the safety valves or other outlets (to reduce the steam pressure pushing the leak to the outside).

As always, allow the boiler to cool, trying to maintain the water level (if possible).

4.- Water Level Variations

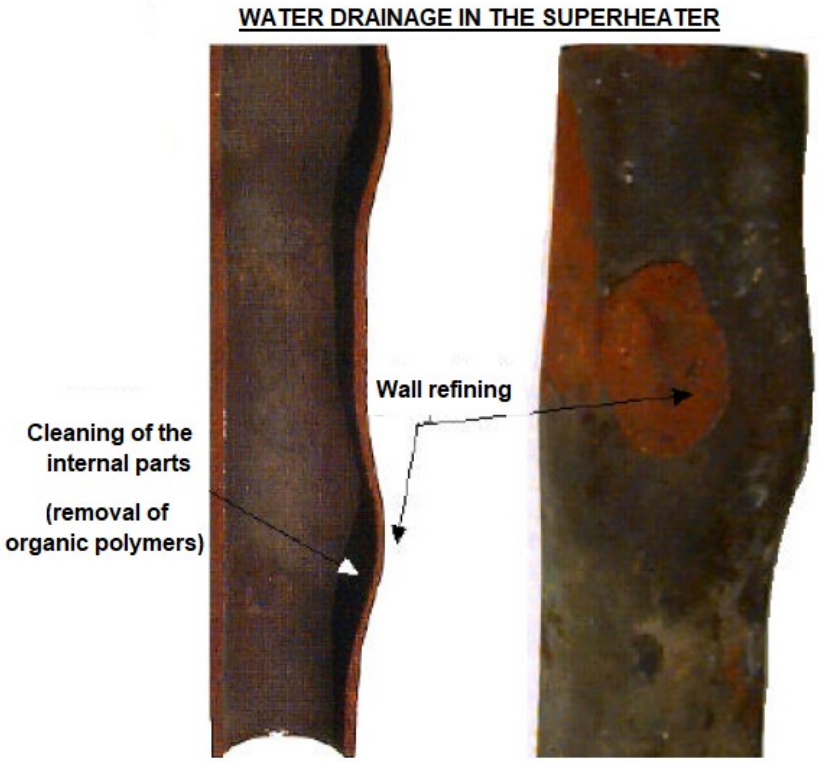
Abnormal variations in water level indicate the possibility of several problems:

a- Excessive (or momentarily excessive) steam consumption. This causes water to be drawn into the steam and can even lead to a low water level in the boiler (a sudden "priming" of water by the steam). Slightly close the steam valve until the level returns to normal (notify production to monitor consumption rationally).

b- Water chemical limits not respected (there may be a high concentration of dissolved or suspended solids, or both, contamination by oils or greases -organic matter-, very high pH, very high alkalinity, etc.).

Purge down the boiler until the levels return to normal (preferably use continuous or surface purge, purging thoroughly, or perform a bottom purge with the burner preferably off or at low heat to remove suspended solids: sludge).

Also purge the levels, especially the electronic ones with conductivity electrodes.



c. Design problems.

In boilers with steam drums or gas generators, if the water circulation (water downpipes) and/or the discharge of the steam produced in them is insufficient, level fluctuations occur.

This is because the tubes in the drums or gas generators tend to vaporize and displace the water inside during periods of high combustion, exacerbated by physicochemical problems in the water. This results in water being displaced into the fire-tube boiler.

Initially, this causes a high level, preventing water from being fed into the boiler. Then, when the water re-floods the drum or gas generator, a low level occurs (the burner shuts down).

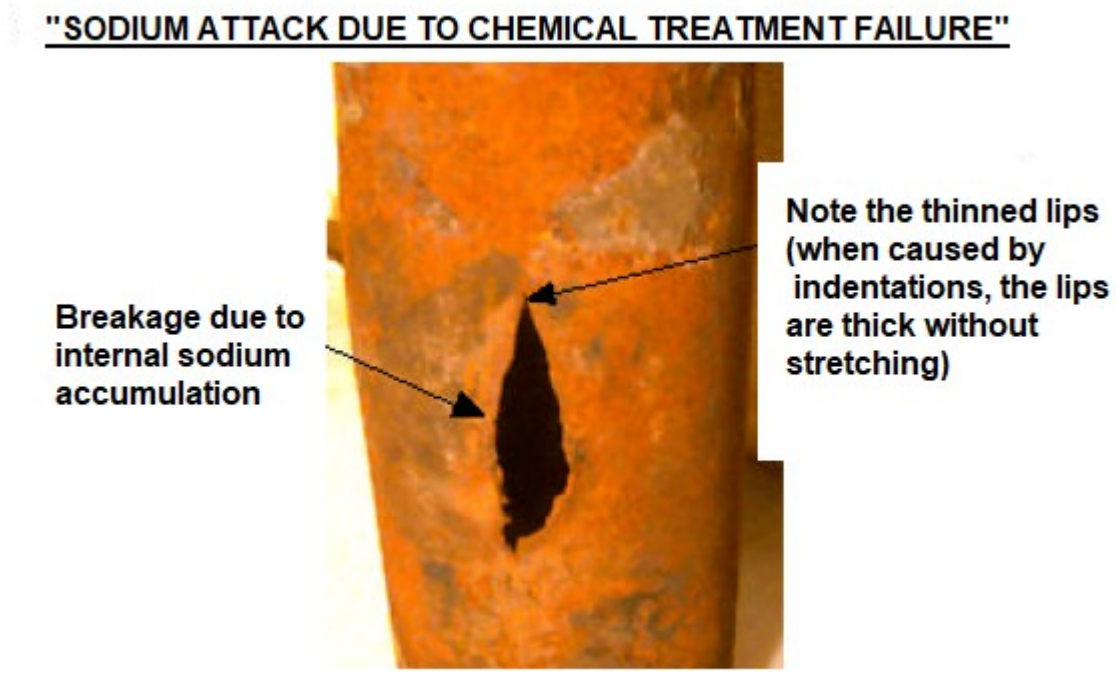
This can lead to unstable boiler operation, with shutdowns due to high levels (if equipped with a high-level cutoff) and low levels (which all boilers have).

When the boiler lacks purge, or there are other chemical limits that are too high (pH, alkalinity, etc.), or some "oils" enter the system, or if the gait is very "strong", this problem worsens.

The aforementioned faults (including c) can lead to a lack of internal boiler water circulation, causing insufficient cooling of the heat transfer surfaces, which, when overheated, can crack or deform due to boiler pressure.

In this case, the combustion chamber of the fire-tube boiler can collapse (cases a and b), since on the fire side the temperature is between 1400ºC and 1600ºC (2912°F) and the metal should not be subjected to more than 450°C (842°F) or less.

This is the job of cooling the water on the water chamber side, whose temperature - the saturation temperature at the working pressure - generally does not exceed 200ºC (392°F) or less. But if the water does not "touch" the metal of the combustion chamber to cool it, due to excessively large bubbles or foam, the metal's temperature rises beyond what the pressure can withstand and it collapses.


"SODIUM ATTACK DUE TO CHEMICAL TREATMENT FAILURE"
Breakage due to internal sodium accumulation
Note the thinned lips (when caused by indentations, the lips are thick without stretching)

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Generally, internal circulation failure is due to insufficient purging (very high alkalinity, very high pH, very high TDS, etc.), or

contamination with elements that alter the water's surface activity, usually organic elements, which in very small quantities produce a significant change in the water, causing foaming.

However, contamination can also occur with inorganic elements from the process, as in the case of dairies or other factories where alkaline elements such as soda are used for equipment cleaning.

Faced with these problems, the first thing observed is a fluctuation in visual levels above normal, so these elements should be purged immediately, especially with the purge valve fully open until the levels stabilize.

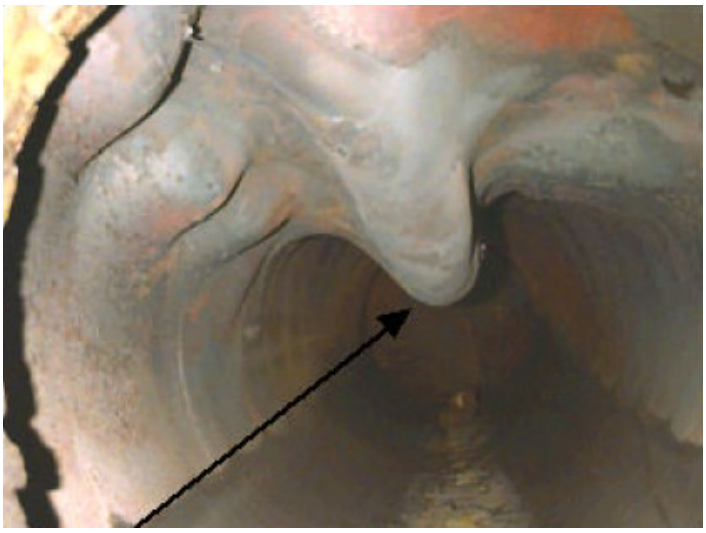
This fault is magnified the higher the combustion rate of the boiler (so it is advisable to lower the steam production, until sufficient purging has been carried out and the reason for the problem has been investigated, by checking the chemical values of the boiler water and feed).

A similar, but not identical, failure to when the boiler runs out of water but the burner remains lit.

BOILER HEART COLLAPSED DUE TO CIRCULATION FAILURE

When the boiler runs out of water and the combustion chamber collapses, a balloon-like "pocket" usually forms over the top of the chamber where the flame is most intense (approximately 1/3 of the length of the burner chamber). In addition, the upper tubes also overheat, twisting due to excessive expansion and often popping out of their mandrels. This results in noticeable excessive overheating in the steam going to the factory, which "burns" any combustible material on the steam pipes, even before the steam pressure has dropped.

In water-tube boilers, these failures cause the tubes to "break" above the furnace, meaning they are more exposed to the flame. This manifests as "balls" or "corns" of fuel in the areas of the tubes most critical for heat transfer. All these problems worsen as the heat transfer surfaces become fouled.



HEART BOILER AFTER A "TOTAL LOW" WATER LEVEL
View from the burner side (pocket formed due to lack of cooling)

If we observe the appearance of furnaces deformed by "low water level" and "circulation failures," we will see that not only is the color of the metal different—in "low water level" it appears more like "burnt metal"—but in "circulation failures," the furnace doesn't fail exclusively from "top to bottom," but can also fail laterally.

There are lateral depressions, which don't necessarily indicate that the furnace overheated more in the upper part, but rather in the areas that are more difficult to cool, that is, where the water has mostly "separated" from the metal due to a "vapor blanket" that insulates it.

This is very noticeable in "torsional chambers," which are an extension of the furnace, in an area of high heat transfer, where, more than deformation, there is often "thermal fatigue" that causes the furnace to crack due to repeated overheating, as well as in the secondary air passage pipes.

d. Combustion Problems

Combustion problems can also be reflected in fluctuations in the water level. In this case, there may be poorly controlled combustion (excessive or shifted combustion) or combustion altered by problems in the combustion chamber or gas passages (broken baffles, fallen refractory linings, etc.), which disrupts internal circulation.

Observe the chimney temperature (if it is the same as usual, if there are smoke readings, etc.). This situation can also lead to failure due to poor internal circulation of the boiler water, with local overheating of the material and subsequent failure due to lack of cooling.

Reduce the combustion rate until adjusted or repaired.

5. Fire in the Boiler Room:

If a fire breaks out in the boiler room, at the burner, or in the vicinity of the boiler: turn off the burner, leave the feed water supply running for as long as possible, and partially close the steam valve to prevent the boiler from emptying. (Obviously, if water is used to extinguish the fire, the electrical power must be cut off.)

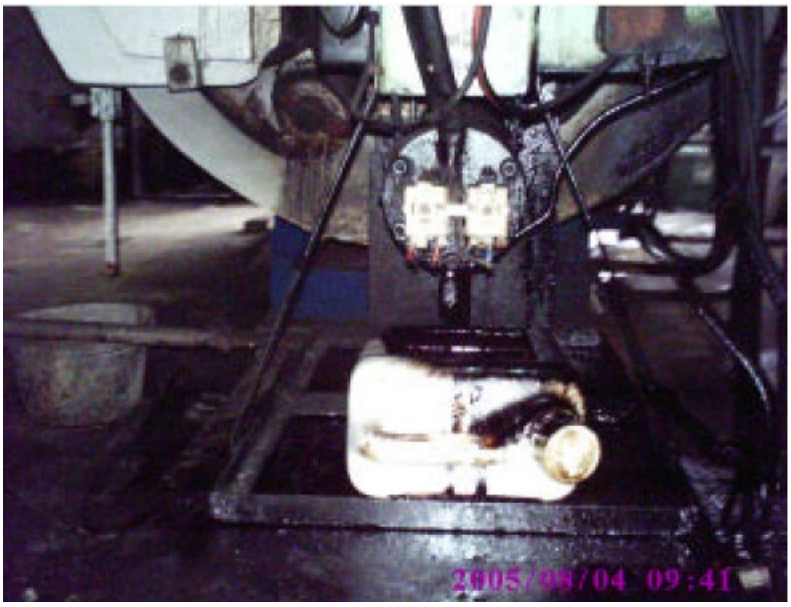
Special attention must be paid to the means of extinguishing the fire, given the variety of fuels used today. The use of water must be very controlled, as there should be no electricity present in the area where water is being used, and sudden cooling of metal structures is not advisable (as it can cause them to deform).

For liquid fuels, it is advisable to have systems using sand, water with foam, powder, and CO2. In some cases, water in the form of spray or steam should be used (when the fire forces the extinguishing of the internal combustion of cellulosic materials, so as not to cause a thermal shock that could lead to further damage).

This issue must be carefully studied before an incident occurs, ensuring not only the means for extinguishing or smothering the fire, but also that all necessary support equipment (personal protective equipment) is available, including alternative escape routes from the boiler room.

It is advisable to have a fire brigade, with the boiler operator as the leader in the boiler area.

It is also essential to have an external electrical power cut-off point outside the boiler room.



Medium Loss and Oil Spill

6. Water in the fuel: (Fuel Oil and similar fuels)

Variations in the flame are noticeable: instability, sputtering, smoke in the chimney (whitish to blackish), and combustion tends to stop.

Sometimes it is possible to continue "burning" this fuel (with excess air despite poor atomization), but once it has been determined that the cause is water, it is preferable to stop and drain the service tank and the supply tank (remove the water from the bottom of the tanks using the valves provided for this purpose or install a pump that draws water from the bottom—if necessary, heat the fuel oil and let it settle for a few hours).
Clean filters and water traps.

The use of fuel additives makes it difficult to separate water from the fuel (if the contamination is less than 1.5% water, this water that integrates into the fuel burns without problems and even promotes combustion).

Therefore, it is advisable not to use additives if the presence of abundant water in the tanks is very frequent.

In some cases of abundant water with additive-enhanced fuel oil, it becomes necessary to completely remove the fuel oil, since it does not separate the water no matter how much it is heated and allowed to settle.

There are some catalytic cracking fuel oils that are heavier than water (density 1 or higher), which do not allow water to be separated. In these cases, it is recommended to add 20% diesel oil, mix, heat, and let it settle to separate the water as the density of the new mixture decreases.

To detect water in fuel:
take a sample of the fuel oil in a test tube (laboratory glass), fill it halfway, and gently heat the bottom of the tube with a flame (rotating it). If water is present, steam bubbles will form and tend to rise. Alternatively, take a sample of the fuel oil in a container and introduce a hot electric soldering iron (only the copper tip) or a heated iron rod (or flat iron) heated to the first color (pale blue). If, upon insertion, "squeaking noises" (like water in a frying pan) and bubbles appear, water is present.

Otherwise:
have the fuel tested by a specialized laboratory (usually the same company that supplies the fuel).

Only by being mentally and physically trained, and knowing the boiler room and the boiler inside and out (with your eyes closed), will we be able to act correctly and in time.

Let's not forget that when there's a power outage (a cut in electrical power at the industrial plant) or when there's steam in the boiler room atmosphere, we often won't be able to see clearly: if the "boiler" doesn't resolve the situation, it's unlikely that someone else will be able to do so without the proper knowledge, and most likely they'll cause a bigger accident by performing the wrong maneuver.

Stoker Boiler Handbook 2011, C.W.T. – CH6 EMERGENCIES

It can be said that every 50 kg of superheated water (at 10 kg/cm², 142 PSI, 183°C, 361°F) can produce an explosion equivalent to 1 kg of gunpowder.

This effect is due to the volume that the steam occupies when it expands at atmospheric pressure.

BOILER EXPLOSION DUE TO LOW WATER LEVEL

The recommendations in this chapter are suggestions for action, **but each boiler and each installation should be thoroughly analyzed beforehand to determine the appropriate response to each emergency.**

Don't forget to have the necessary fire safety equipment, personal protective equipment, and tools readily available for these emergencies: a boiler emergency doesn't leave much time to think and act.

Boiler hazards are directly linked to inadequate equipment maintenance, especially regarding the condition of the water-contact surfaces (scale and sludge buildup) and safety features (primarily proper water levels and safety valves).

A clean and well-maintained boiler is efficient and safe. A trained and conscientious boiler operator can address any risks that could endanger their safety.

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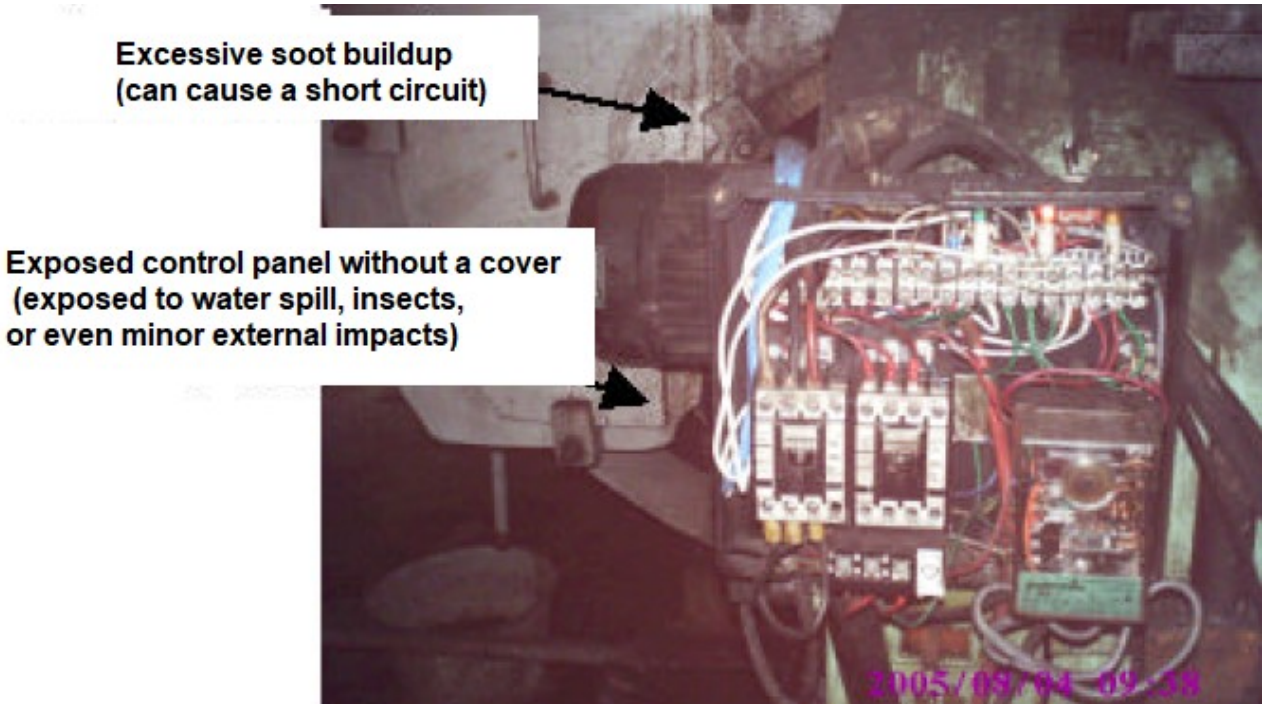
As in all human activity, ORDER AND CLEANLINESS are the base of the pyramid for the best productive results, taking care of human life and the environment.

Effect produced by the explosion of a container subjected to pressure with steam (fat digester)


Excessive soot buildup
(can cause a short circuit)
Exposed control panel without a cover
(exposed to water spill, insects,
or even minor external impacts)

A BAD EXAMPLE OF BOILER MAINTENANCE